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The Editor's Page

THE BOARD OF DIRECTORS of U. S. Institute held their second quarterly meeting at the Hotel Pennsylvania, New York City, Tuesday, March 16, First Vice-president E. H. Killheffer presiding in the absence of the President. Thirty-one new annual and 41 new contributing members were elected. Chairman Emley of the Research Council in his capacity as chairman of the committee on the drying research reported that this study was ready for organization and that the committee recommended for the place of the study the National Bureau of Standards. The recommendation was approved, and an administration committee of three members was elected as noted in another column of this issue.

The refinancing of the study on sizing and sizing materials was reported by the Secretary completed as of Jan. 1, 1937. Chairman Bolton of the administration committee for this study reported satisfactory progress considering that there had been unavoidable delay in starting mill experimental work. Two new slashers have been installed and completely instrumented for high-temperature and high-speed processing, also latest type looms for rayon weaving. Meantime, the laboratory has proceeded with analytical work on sizing materials, and the testing of unsized, sized and desized fabrics; the results will be given in a report now being prepared by Director Yelland.

* * *

THE "Critical Study of Cotton Manufacturing Processes," conducted by R. L. Lee, Jr., as a Senior Fellow of the Textile Foundation, the final report of which appears in this issue, may be accepted as proving that doubling decreases the variability of the count of cotton strands within short distances, but that in actual practice any advantages derived from doubling may be offset by the irregularities produced by drafting. Lee's work confirms theories previously advanced by A. J. Turner and W. Lawrence Balls, who had worked in England on similar problems. On the other hand, there are some research authorities who disagree—at least as to the point in the sliver-forming processes where the advantages of doubling are seriously offset by drafting; some claiming with the second drawing; others with the third. The manufacturing trend, however, is toward the reduction of the number of machines and of doublings beyond the first or second drawing. This apparent lack of agreement with Lee's findings should be explained. These columns are open to constructive criticism based upon scientifically accurate data.

* * *

THE theory of moisture adsorption, absorption and desorption of cotton and other textile materials is basic to the study of textile drying that has been organized by U. S. Institute and is to be conducted at the National Bureau of Standards. The article by Dr. A. C. Walker, of Bell

Telephone Laboratories, published in this issue will, therefore, be found of unusual interest by those who are co-operating in the drying study, and by others who apparently are not conscious that they have a drying problem. While Dr. Walker frankly admits that certain parts of his article are merely "a proposed explanation" of moisture adsorption, nevertheless it is in large part a report of scientific findings that will be generally accepted. Dr. Walker's ability and work are well known to many textile research men, but to others of the industry who have heard of him only since acceptance of his appointment as a member of U. S. Institute's administration committee for the textile drying study, this article will be a fitting introduction.

* * *

A NATIONAL Rayon Technical Conference is to be held in Washington, D. C., May 14 and 15 under the auspices of the Textile Division of the American Society of Mechanical Engineers, and the co-operation of U. S. Institute for Textile Research, American Association of Textile Chemists and Colorists and Committee D–13 of the American Society for Testing Materials. It is designed to bring together members of scientific and technical organizations for discussion of various problems of common interest involved in the manufacture of rayon and its products. An informal dinner will be held May 14 at the Wardman Park Hotel, the headquarters of the conference. Papers on the following subjects are to be presented and discussed: Air conditioning of textile plants making and using synthetic yarns; mechanics of synthetic fibre weaving; throwing of rayon yarn; dyeing and finishing of rayon and acetate fabrics; testing of rayon and acetate yarns and fabrics; manufacture and use of cut rayon staple; use of corrosion-resistant metals and alloys in rayon equipment. The conference is open to all who are interested and further details may be obtained from M. A. Golrock, Jr., Sec., A. S. M. E. Textile Div., 29 West 39th St., New York, N. Y.

* * *

B. H. WILSDON, director of research, British Research Association for the Woollen and Worsted Industries, comments as follows in his 1936 annual report on two important results of research at the Torridon laboratories: "We possess a key patent, and filed during the year a subsidiary application, which covers the employment of a gaseous chlorination process for the production of unshrinkability in wool. Recent technical developments have now reached a stage where release for the treatment of wool in top or at previous stages of manufacture has been recommended after careful examination by the technical panel which has been considering the results. It remains only for the Association to complete the business arrangements whereby its members will be able to take up the process on a commercial scale. This is a development which should benefit all sections of the industry and not only those immediately concerned with the application of the process. By endowing the wool fibre itself with new characteristics new fields of use open out where wool has previously only been employed with difficulty, besides those in which it will replace less efficient methods of processing."

The Research on Textile Drying

Co-operators to Meet and Discuss Final Plans for the Study

DRYING of textiles is to be studied at the National Bureau of Standards under the auspices of U. S. Institute for Textile Research, and the supervision of the following administration committee: G. E. Hopkins, technical director, Bigelow-Sanford Carpet Co., chairman; Dr. A. C. Walker, Bell Telephone Laboratories, and Dr. F. Bonnet, The Viscose Co. The Administration Committee and representatives of the Bureau of Standards for this study will select a director for the research, and prior to the starting of actual work a meeting of co-operators will be held in Washington, D. C., at which they and those responsible for the study, including the Research Council of U. S. Institute, will confer regarding the research program and its possible revision or expansion, and the selection of an advisory committee for the study. Co-operators will also have an opportunity to inspect the laboratory and other facilities at the Bureau of Standards for this work, and to learn of other drying studies that have been conducted there and of their results.

The drying research was made possible by 50 co-operators, the income of whose contributing memberships ($100 a year each) are credited to an initial fund of $5,000. These co-operators and others who may yet become contributing members for this study will receive confidential progress reports of results, and these reports will not be published until a year after completion of the study. In view of the many features of this research for which there is no scientifically reliable information, and of the vital importance of safe and efficient drying in textile processing it is expected that the number of contributing members for this study will be largely increased now that the main details of its organization are known.

The purposes of this study are briefly described in the program as follows: "To ascertain some of the fundamental facts underlying the design of drying equipment for textiles. To develop information about the way textiles can be dried with maximum efficiency and minimum injury to the material. To assist in applying this information in individual plants."

The problems to be studied are (*a*) regain, (*b*) effect of regain, (*c*) effect of machine variables, (*d*) effect of impurities.

As soon as results are ready for practical application, co-operators may have the advantage of the advice of the director on a consulting basis, the latter visiting their mills and conferring with their technicians when deemed requisite. The latter is a service made available for the first time in connection with U. S. Institute researches. This also is the first co-operative research of U. S. Institute that has been wholly financed by members.

Like other co-operatively financed studies of U. S. Institute the drying research was approached by an open conference of all interested parties, held in May of last year in New York City. By unanimous vote U. S. Institute was requested to proceed with the preliminary organization and financing of the study. A committee consisting of W. E. Emley, chairman, Alban Eavenson and Dr. H. DeW. Smith has had charge of initial plans, and Secretary C. H. Clark of the financing. Another open

(*Continued on P. 261.*)

Moisture Adsorption in Cotton and Other Fibrous Insulating Materials: A Proposed Explanation

ALBERT C. WALKER *

Introduction

CERTAIN properties of cotton have led to much speculation regarding the structure and the manner in which moisture is held within the body of the cotton hair.† Some of these properties may be listed as follows: A small amount of water is adsorbed by dry cotton more rapidly than the same amount added to cotton with a moderate water content. This initial amount of water affects the elastic properties and heat of adsorption to a much greater extent and is more difficult to remove on drying than the same amount added to cotton already containing some moisture. If cotton or other moisture-sorbing ‡ materials, such as wood, paper or fibre board, are dried below a certain critical moisture content, permanent changes may be expected, and even serious damage may result from too thorough drying. The electrical insulating properties of cotton at any equilibrium moisture content are critically dependent upon this moisture and also upon the previous history of the material, particularly the manner in which it is dried from the wet state. The cotton hair swells more than 20% in diameter in passing from the dry state to saturation in water, while the length increases by not more than 1%.

In this paper an attempt is made to explain these properties of cotton. Based on assumptions, first as to the structure of the cotton hair, then as to the location and distribution of the internal surface upon which moisure might condense, calculations have been made as to the moisture content and swelling of cotton at various equilibrium conditions, employing some additional assumptions as to the manner in which moisture is held upon this internal surface.

From this rather specific picture of the cotton hair structure it has been possible to calculate moisture contents and swelling properties consistent with experimental data. It has been possible, also, to present a more comprehensive explanation of the change in the relations between electrical resistance and moisture content of cotton over the whole range of atmospheric humidity than that given in previous publications from these Laboratories.[1, 2] It is, therefore, considered that such a picture

* Bell Telephone Laboratories, New York, N. Y.

† In keeping with recognized terminology, the individual cotton fibre is called a hair, suggestive of its morphological origin.

‡ "Adsorption" is here defined as the taking up of a gas or vapor by a solid, "desorption" the giving up of a gas or vapor, and "sorption" the general process without special indication of gain or loss. The use of these terms implies no assumptions with regard to the mechanism of the processes they denote.

should contribute much towards a better understanding of the moisture sorbing properties, not only of cotton, but also of other similar fibrous materials, despite the hypothetical nature of some of the assumptions upon which the calculations are based.

Structure of the Cotton Fibre

According to Balls,[3] the cotton hair is formed by the outward extension of a single cell from the epidermis of the seed-coat; this extension, unaccompanied by any cell division, may continue until the hair is 2000 times as long as it is broad. Since the cotton hair length has a mean value of about 1 in., its diameter, roughly estimated, is about 0.0005 in. (0.0013 cm.). Up to about half maturity, the cell wall remains very thin but the hair attains most of its length; during the remaining half of the growth period (about one month) the wall thickens from the outside in until it appears to consist of about 30 to 35 concentric "growth rings." Each growth ring consists, further, of parallel strands of fibrils, which run continuously in spiral form from end to end of the hair making one complete turn around the hair in about three diameters, and with periodic reversals in the direction of this spiral. Balls also suggests that side by side in each growth ring, there are about 100 fibrils, each separated from its neighbor by an air space. These fibrils are described by Balls as "dominos"* laid down one on top of the other in a pile-up of growth ring units extending from the wall of the central canal or lumen to the outer wall of the fibre. Thus the front and back of each domino are growth ring boundaries, and each domino is separated from its neighbor by an air space. There are also air spaces between each domino in a growth ring. These air spaces are identified as the so-called pits in the wall structure. They are visible under a microscope, and appear to extend from the outer surface of the cotton hair down to the lumen. These air spaces are far larger in magnitude than those separating the front and back of each domino. Only by swelling the fibre in caustic soda can a differentiation be detected in the cross-sectional structure of the fibre to indicate this growth-ring character. Thus the fibrils are considered as being separated by air spaces on all sides; the whole cotton hair is spongy, and the surfaces of cellulose bounding these air spaces are internal surfaces of the fibre.

Slip spirals are visible in the hair surface at high magnification. Though decidedly irregular, they appear to cross the pits at approximately right angles, suggesting that there are additional internal surfaces at these points.

Fig. 1 (*a*) shows an idealized cross-section of the cotton hair, with the domino cross-sections arranged according to Balls' conception. The side view (*b*) shows the spiral arrangement and spiral reversal of the fibrils and the pits, together with the slip spiral effect.

Obviously these conventional type figures are not representative of

* These "domino" shapes are not conceived as being real unitary structures, but simply descriptive models. Furthermore, whether or not the pits are factual or are distributed as random air spaces between fibrils makes little difference for our purpose, so long as the ratio of cellulose to air space is of the right order of magnitude, consistent with the apparent density of cellulose. It is convenient for calculation to picture the cotton hair section in this way.

the shape of the cotton of commerce,* although they approximate the shape during the growth period, before the boll is opened. As the hair dries out, the lumen collapses and the hair twists.

Cellulose from all sources appears to consist of definitely arranged crystallites or micellae.† Sponsler and Dore,[6] Meyer and Mark,[7] Freuden-

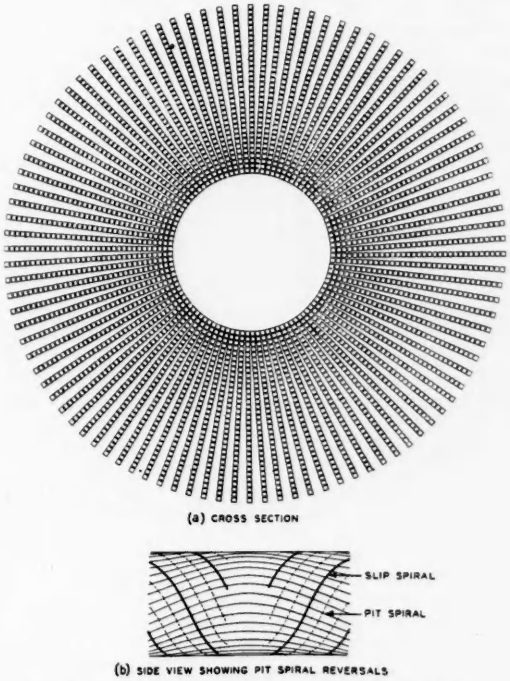

FIG. 1. Idealized Structure of the Cotton Hair.

berg,[8] Herzog[9] and Polanyi[10] have contributed much to the present conception of the chemical and fibrous structure of cellulose. Haworth[11] suggested that cellulose is composed of an elementary group consisting of two $C_6H_{10}O_5$ units, called cellobiose (Fig. 2-*a*), and Fig. 2-*b* indicates how these

* Clayton and Peirce[4] made a frequency distribution of hair shapes and sizes of a soda-boiled Texas cotton of the type used in securing some of the data upon which the calculations made subsequently depend. They showed sketches of 11 different hair cross-sections, and emphasized that no one shape was representative. Peirce[5] suggested that a rectangle capped by 2 semicircles gives the geometrical approximation to the mean effective shape, but the symmetrical shape pictured in Fig. 1 is preferred for purposes of calculation.

† At the present time the term crystallite is being used rather than micelle, so as to suggest the crystalline nature of the sub-microscopic structural unit. In general, the two terms are used interchangeably.

cellobiose units are jointed together end to end to provide the fibrous structure of native cellulose.

In cotton and wood celluloses the crystalline chains which comprise the fibrils are spirally wrapped along the fibre length (see Fig. 1-*b*). The most reliable calculations of the unit cell dimensions in cellulose is secured from ramie, which has less tendency to spiral than cotton. X-ray data for this material give unit cell dimensions of $a = 8.3$; $b = 10.3$; $c = 7.9$ AU, and the structure is rhombic with $\beta = 84°$.

Diffraction and chemical evidence indicate that the cellobiose units are arranged parallel to the *b*-axis of the unit cell, with one cellobiose group at each common edge of adjacent cells and one through the center of each cell. These form long primary valence chains arranged parallel to the fibre axis and held together laterally by cohesive forces. Fig. 3 shows this conception of the unit cell as given by Meyer and Mark.[7]

Fibre and Structure Dimensions

Clayton and Peirce,[4] from their frequency distribution, computed the mean area of the cotton hair cross-section as 1.36×10^{-6} cm^2 at 40% R.H. From experiments on swelling with this same cotton, they estimated an increase in mean diameter of the hair of about 0.14% per unit of R.H.* Thus at 40% R.H., the cotton hair is 5.6% larger in diameter than when dry. This is equivalent to 11% increase in mean area of the cross-section, so that the dry hair would have an area of 1.23×10^{-6} cm^2 and a mean diameter of 1.25×10^{-3} cm (equivalent to 125000 AU).

Balls estimates the mean area of the lumen as roughly 10% that of the hair. Therefore, the mean diameter of the lumen is estimated to be 39500 AU, the wall thickness 42750 AU, and the circumference of lumen and hair, respectively, 124000 and 392000 AU.

The fibrils are pictured as arranged in "pile-ups" estimated as about 100 in number around the lumen circumference, each pile-up alternating with a pit area. Assuming the pit as having zero width at the lumen circumference, and a maximum width at the hair surface, the cross-section of this pit is a long narrow triangle (Fig. 1-*a*). The width of each fibril is, therefore, 1/100th that of the lumen circumference, or 1240 AU. Since the number of growth rings is estimated at between 30 and 35, a mean of 33 is assumed, and this gives a fibril depth of $42750/33 = 1300$ AU. The maximum pit width is 1/100 the difference between hair and lumen circumferences, or:

$$(392000–124000)/100 = 2680 \text{ AU.}$$

Moisture Adsorption

A.—On Fibril Surfaces

It appears reasonable to assume that moisture will first adsorb on dry cotton on the outer surface of the hair, and by diffusion in the vapor state will penetrate into the pits and adsorb on the pit walls. Since cot-

* Collins [12] gives but 0.11% increase in hair diameter per unit R.H. A comparison of the two sets of swelling data indicates Collins to be the more consistent. Therefore, in subsequent calculations, Collins' data will be used. The mean diameter of 1.25×10^{-3} was obtained using Clayton and Peirce figures on their own test sample, simply to be consistent within the one set of data. Using Collins' factor would give a slightly larger mean diameter, but would make no essential difference in subsequent calculations.

ton swells appreciably in a transverse direction, but hardly at all lengthwise, it is further assumed that moisture in the pits will next penetrate along the growth ring surfaces. At equilibrium with any humidity below that required to form a monomolecular layer, it is assumed that the water molecules will be distributed uniformly over all of the internal surface. For humidities above this value, polymolecular layers of uniform thickness are assumed to form on the fibril surfaces only, since moisture on the growth ring surfaces of these fibrils appears to be responsible for the transverse swelling of the cotton.

The equilibrium moisture content of cotton is reduced if the hydroxyl groups on the cellulose molecules are acetylated or otherwise esterified. The decrease in moisture adsorption is approximately proportional to the degree of esterification.[13] Experimental data showing this relation are given in Table 2, together with calculations based upon the cotton hair structure, which show that the moisture decrease is consistent with the decreasing number of available hydroxyls on the internal surface of the hair. Consequently it seems reasonable to assume that each water molecule adsorbed on the cellulose surface is held by a force originating in the oxygen atom of a surface hydroxyl group. As may be seen from Fig. 2, there are six hydroxyl groups per cellobiose unit, and the percentage moisture equivalent to a monomolecular layer covering the surface of the fibril structure with each water molecule satisfying forces of a surface hydroxyl oxygen is calculated as follows:

The fibril cross-section is estimated to be 1240×1300 AU. Assuming the cellobiose units arranged with the a-axis parallel to the fibril width, there will be $1240/8.3 = 150$ unit cells across the fibril, and $1300/7.9 = 165$ unit cells down through the fibril. Therefore the total number of oxygen atoms per unit cell length, in the four fibril surfaces, is:*

$$6 \times 150 \times 2 + 6 \times 165 \times 2 = 3780.$$

Assuming each hydroxyl oxygen has sufficient attractive force to hold but one water molecule, the percentage moisture required to form a monomolecular layer is estimated simply from the ratio of total hydroxyls thus calculated to total cellobiose units in a unit cell length of fibril, this ratio multiplied by the molecular weight ratio of water to cellobiose:

$$\frac{3780}{2 \times 150 \times 165} \times \frac{18}{324} \times 100 = 0.42\%$$

B.—Hair Swelling Due to Fibril Surface Moisture

The diameter of the water molecule is reported as 3.8 AU. In order for a monomolecular layer to be held on the surfaces of the fibrils which face one another along the growth ring boundaries, these surfaces must be separated at least $2 \times 3.8 = 7.6$ AU. This corresponds to a total increase in hair diameter of $33 \times 2 \times 7.6 = 500$ AU. Therefore the per-

* From Fig. 3 it appears that only the equivalent of one cellobiose unit may be available for surface moisture adsorption per unit cell in the fibril surface. The second cellobiose is at the center of each surface unit cell, and therefore should not be considered. Furthermore, since molecules in solid or liquid surfaces are subjected to unbalanced forces not present within the material—surface tension forces—it seems reasonable to assume that all surface cellobiose units are so oriented that all six hydroxyl groups have surface forces capable of adsorbing water molecules.

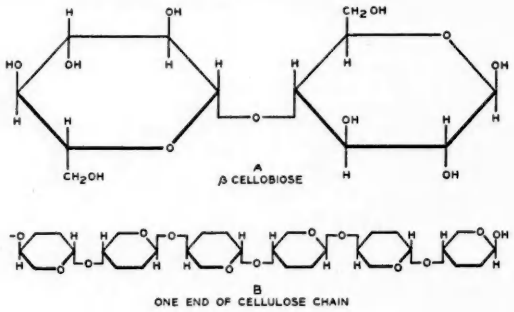

FIG. 2.

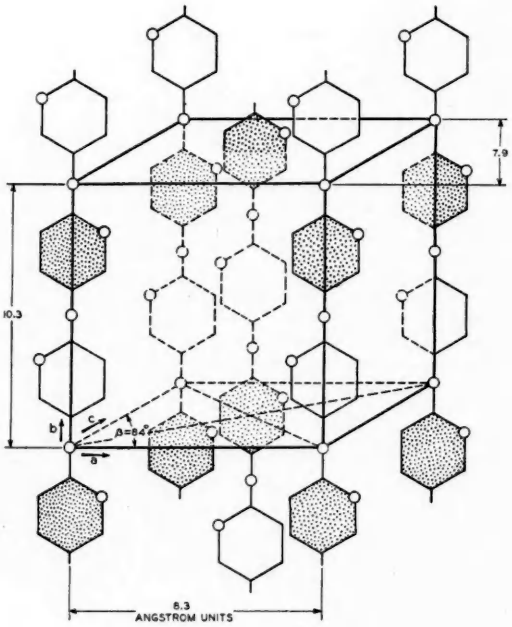

FIG. 3. Cellulose Unit Cell.

centage diameter increase of the hair is:

$$(500/125000) \times 100 = 0.4\%$$

According to Collins[13] the coefficient of hair diameter increase with humidity is about 0.11% per 1% R.H. Therefore, an increase of 0.4% in hair diameter is found at $0.4/0.11 = 3.6\%$ R.H. From adsorption data in Fig. 4 (Urquhart and Williams[14]), this relative humidity corresponds to between 1.1% and 1.2% moisture content. The difference in moisture content at this point and that calculated under section A for a monomolecular layer on the fibril surfaces is between 0.7% and 0.8%, suggesting that there is additional internal surface within the hair structure upon which moisture may be held. This suggestion appears to be confirmed from quite different considerations.

Brunauer and Emmett[15, 19] consider it likely that the linear portion of van der Waals adsorption isotherms for nitrogen on the surface of iron synthetic ammonia catalysts indicates the building up of a second layer of adsorbed molecules. They state that extrapolation of this linear portion to zero pressure indicates the amount of gas needed to form a monomolecular layer upon this surface. Between 3% and 50% relative humidity, the adsorption isotherm for cotton in Fig. 4 is very nearly linear. Applying this method to cotton the intercept (*a*) has values between 1.4% and 0.35%, depending upon temperature.[16] The average value is about 1% MC, being of the same order as that estimated from swelling data.

Since the estimated moisture content equivalent to a monomolecular layer on the internal surface of the cotton hair is so nearly the same when determined by two independent methods, it seems reasonable to postulate an additional internal surface in the cotton hair, amounting in extent to somewhat more than that corresponding to the fibril surfaces.

C.—Location of Remaining Internal Surface

Since the additional internal surface suggested by the above considerations does not appear to be involved in the transverse swelling of the cotton hair, it is of interest to speculate as to its location.

Astbury[20] pictures an idealized diagram for swelling of a textile fibre based upon moisture being adsorbed on surfaces of crystallites which are of the order of 200 AU thick by 20 times this length, since the increase in diameter of a fibre is about 20 times that of the length during moisture adsorption. The transverse swelling of the cotton hair estimated for a monomolecular layer on the sides of such crystallites gives much too high a value consistent with the considerations under section B. This is one reason which led the writer to investigate the possibilities of the picture set forth in Fig. 1.

There is some evidence in the cotton hair structure for giving serious consideration to the adsorption of moisture on the ends of crystallites such as pictured by Astbury. Slip spirals along the hair, crossing the pits at approximately right angles (see (*b*) of Fig. 1), suggest that there are discontinuities in the length of the fibril structure, hence further internal surface. This surface may be upon ends of fibril cracks, perhaps upon the ends of all of the smaller elements or crystallites.

If we assume monomolecular adsorption on all ends of elements 200 AU wide by 4000 AU long, the moisture content is much less than 0.1%. It appears, however, from X-ray data on ramie that the crystallite dimensions may be somewhat less than these, which were based upon work done on the wool fibre.

Hengstenberg and Mark [21] once concluded from X-ray data on ramie that the micelle (or crystallite) is a slender, rod-like aggregate of parallel cellobiose chains, about 50 AU broad, by at least 600 AU long.

Similarly, they estimated the dimensions of rayon crystallites as about 40 × 300 AU. Estimates for crystallite dimensions in cotton are more difficult due to the spiralling of the hair structure, but considering the difference in physical strength of cotton and ramie, it appears reasonable to expect that the structural elements might be shorter in cotton than in ramie. A monomolecular layer on the ends of such crystallites equivalent to between 0.7% and 0.8% moisture content would require dimensions of

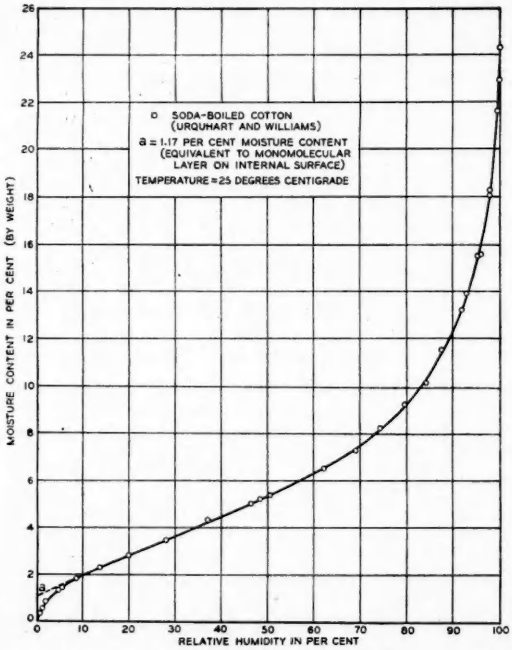

FIG. 4. Moisture Absorption Isotherm for Cotton at 25° C.

about 50 × 150 AU. It is considered of much less importance for the purpose of this paper to pursue the possibilities of this line of speculation further than it is to simply point out that some such distribution of surface within the body of the fibril structure may be involved in adsorption of some moisture, and this picture is of material use in helping to account for some of the properties of cotton.

D.—Multimolecular Layers

Polanyi's [22] potential theory of sorption of gases by solids postulated a thick film of compressed or liquified gas on the surface of the solid. This

was considered, at first, to hold only for the region concave to the pressure axis where probably less than a molecular layer of gas exists, and for the linear portion upon which more than one layer would condense. Above this linear portion—for cotton this corresponds to about 50% R.H. —the increasing steepness of the curve was supposed to represent capillary condensation. Hückel [18] states that as a consequence of Goldmann's experiment Polanyi modified his view and considered that the last portion of the curve corresponds to sorption also, and not to capillary condensation. From discussion to be given later in this paper it seems likely that both sorption and capillary condensation may occur together under certain conditions.

At any rate it is assumed in the present discussion that further adsorption of moisture by cotton above 1.5% moisture content in curve 4, simply increases the thickness of the layer on the internal surface. The thickness (n) of the moisture layer on each fibril, expressed in number of water molecules, and the percentage moisture content at 50% relative humidity is obtained as follows:

At 50% R.H. the hair diameter increase is 5%—plot of Collins' data. Using the following equation formulated in accordance with the calculations in section B:

$$n = \left(\frac{500}{100} \times 125000\right) / 7.6 \times 33 \times 2 = 12 \text{ molecular layers.}$$

Since a layer one molecule thick on the fibril surfaces is equivalent to 0.42% moisture content, 12 such layers is equivalent to 5% moisture. This is somewhat less than the observed moisture content at this humidity, which is 5.5%. If similar thickness of layer at this humidity is assumed on the additional internal surface, pictured, for example, as being on the ends of crystallites, the total moisture would be much too high. However, if it is assumed that this additional surface may hold but one molecular layer at all humidities above the monomolecular layer equilibrium point, the total moisture content at 50% R.H. would be between 5.7% and 5.8%, which checks much more satisfactorily with the observed value of 5.5%. This assumption appears the more valid if it is considered that the cotton hair swells to such a small extent in the lengthwise direction.

In this discussion it is assumed that each water molecule in the initial layer is held at some active point or zone upon the surface. It is not to be concluded, however, that once a monomolecular layer is established on the surface, that a continuous film exists. It appears that some space is still available between adjacent water molecules, and the space-pattern of water distribution is determined by the type of solid surface and the arrangement of the active points or zones. In the case of cotton, the active points are hydroxyl groups; for silk they may be amino or carboxyl groups or both, and from Astbury's [13] discussion of the chain structure of these two materials it seems likely that the space-pattern would be different for moisture adsorption on these two textile fibres.

Furthermore, it is assumed that this space-pattern is carried out for increasing layers of water molecules, each molecule in the successive layers being held by one in the layer immediately beneath. This conception is much like the picture of long-chain acid or oil molecules standing as a film on a water surface, with the polar end in the water. Such water chains are not compressed to a minimum surface coverage consistent with

the water molecule width, since the base of each water chain is held at separated points on the solid and not on a mobile liquid.‡

E.—At Saturation

Collins reports swelling values of 42% in the cross-sectional area of cotton exposed to water vapor (some condensation was visible on the cotton in this test), and 49% when immersed in liquid water. Corresponding diameter increases are 19.2% and 22.2% respectively.

Calculating as before:

At 100% R.H. : $n = 48$ layers; $48 \times 0.42 = 20\%$
$20 + 0.8\% = 20.8\%$ total moisture content.

In Liquid H^2O : $n = 55$ layers; $55 \times 0.42 = 23\%$
$23 + 0.8\% = 23.8\%$ total moisture content.

The author secured an experimental value at saturation, of 20.7% moisture content under conditions where condensation of moisture was a minimum.[1] Urquhart and Williams [14] reported 22.97%, and more recently Urquhart and Eckersall [25] reported 25%, under conditions where dew was visible on the cotton. It seems reasonable to conclude from this that the value at saturation, in the absence of accidental condensation due to minute changes in temperature is more nearly 20% than 25%, and as will be seen from subsequent calculations, much more moisture than this apparently can be held within the cotton hair *without further swelling.*

F.—Hair Size

There are, of course, various possibilities as to the effect of hair size on moisture distribution according to this theory. To illustrate this, some calculations have been made similar to those in sections A to E, for a hair of maximum diameter (270000 AU). For simplicity only two of these possibilities will be considered. The results are given in Table 1.

TABLE 1
Calculated Moisture Contents of Cotton
(*Percentage of dry weight*)

Hair Diameter AU	Monomolecular layer			Multimolecular layer	
	Fibrils	Other Surface	Total	Total—50% R.H.	Total—Saturation *
125000	0.42	0.8	1.2	5.8	23.8
270000 †	0.2	(a) 0.8	1.0	6.2	24.6
		(b) 1.0	1.2	6.4	24.8

* Based on swelling data for wet cotton.

† In these calculations it is assumed that the larger hair has the same number of fibrils and growth rings as the average hair. Thus the individual fibrils will be larger in both cross-sectional dimensions and the moisture corresponding to a mono-molecular layer on the surfaces will be inversely proportional to the hair diameter. The values listed as (a) are based on crystallite dimensions being the same in both hair sizes. The (b) values are secured by estimating the crystallite moisture content as being the difference between the average intercept value and the fibril value for the larger hair. In this case the larger hair is assumed to be composed of smaller dimension crystallites.

‡ This seems consistent with the idea discussed by Bückel [18] as a modification of the Polanyi potential theory, and others, that different points on a sorptive surface exhibit variations in activity towards sorbed molecules. Also see the summary by McBain [24] on attractive forces acting only between one sorbed molecule and that immediately beneath it in the sorbed layer.

From this it seems possible that the total moisture content at any humidity is not significantly dependent on hair dimensions, except perhaps at low humidities.

(*To be concluded*)

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Science and Empiricism

Glass fibre developmental work, the properties and character of fibre now available, and the types of textiles for which it is adapted, were described in a frank and interesting paper delivered by D. C. Simpson, of the Owens-Illinois Glass Co., at a recent luncheon meeting in New York of the Textile Square Club (*Daily News Record* (1937), Feb. 1, P. 10; Feb. 2, P. 12). The principal present use of glass fibre is for insulating and filtering purposes. However, fibre .0002-inch in diameter is being produced commercially and in continuous filament yarns as fine as 35s cotton, also in staple yarns with a 15-inch fibre length drafted to approximately 60s cotton count. These yarns are adapted for weaving into various kinds of cloths, tapes and braids for industrial uses in which their fire-resistant, acid-resistant and insulating properties are essential. Glass fibres are non-elastic and gain but little elasticity in twisted yarns; they also lack resistance to flexing and to abrasion, and are therefore unsuited for use in clothing materials. The same factors also render weaving difficult. Dyeing has not proved practical thus far, but encouraging progress has been made in the production of a variety of colored glass fibres. The company is proceeding cautiously in its developmental work, and, while welcoming the opportunity to aid and protect those who suggest new uses for glass fibres, prefers to conduct experimental work in its own plants where specialized apparatus and trained personnel are available.

* * *

Blue stain on cotton has been traced by O. P. Owens of North Carolina State College to a fungus belonging to the *Alternaria* family. Pure cultures of the fungus planted on sterile mature cotton fibres invariably produced the blue stain.

* * *

Banana fibre has been recovered from the skins of the fruit and spun by the Viscoria Mill, Manchester, Eng., according to a dispatch to the United Press. The yarn is described as soft, light, fluffy and having elastic and uncrushable qualities. For use in dress goods it is twisted with about 45 percent filament rayon.

* * *

Typewriter ribbon of Bemberg rayon, marketed under the trade mark, Cello-Cilk, is credited by a news item in the *Daily News Record* with the following qualities: Holds ink without drying out longer than silk or cotton; is lintless; will not pack on the type, and is so thin that twice the usual number of carbon copies can be made.

* * *

Mercerized cotton yarns are being subjected to a scientific study of their breaking strength and stretch at the National Bureau of Standards under the auspices of the Mercerizers' Association. Need of the study was suggested by the National Association of Hosiery Manufacturers.

* * *

Drying is the limiting factor which, in most instances, controls the speed of production in printing.—Many plants can increase their production from printing machines from 35 to 40% by changing their drying equipment better to meet present-day requirements.—*Textile World.*

(*Continued on P. 250.*)

A Critical Study of Cotton Manufacturing Processes

The Effect of Doubling of Strands Upon Their Irregularity*

By R. L. LEE, JR.†

Fellow of the Textile Foundation

Conclusions

Doubling does improve uniformity of counts of cotton strands. Graphs of the average of 6-inch lengths of sliver taken from random spots show that number irregularity is decreased as the strands are doubled through successive manufacturing processes. The combinations of the weights of the random spots according to the cans (sliver) from which they were taken show much less spread around the mean of the mass after having been doubled through each successive process. These results are mathematically logical.

Results indicate that doubling also decreases the variability of cotton strands within short distances.

Calculated or expected "after doubling" variability was determined by dividing the "before doubling" variability by the square root of the number of strands doubled. Correlations between the actual and the expected results are very high, and indicate that the degree of reduction in variability by doubling is equal to the reciprocal of the square root of the number of strands doubled.

Introduction

TWO forms of irregularity in strands of cotton are ordinarily recognized in yarn manufacturing; namely, irregularity of number or count (variation over long lengths), and irregularity of profile (variation within short distances). Doubling, the feeding of two or more strands together at a machine to produce only one, is often employed in attempting to reduce irregularity among the various strands produced by the machine. That doubling, merely another form of mixing, reduces irregularity in, or averages, the number or count among the strands is very logical, but that it reduces profile irregularity in thickness over short distances in the strands is not so easily discerned. Turner[1] has written:

* This report is the fourth of a series of studies of irregularity in cotton strands under the general title "A Critical Study of Cotton Manufacturing Processes." *Tex. Rsch.*, Vol. IV, No. 5; Vol. V, Nos. 4, 7.

† As a Senior Fellow of the Textile Foundation Mr. Lee worked under the direction of Prof. H. J. Ball, Head, Dept. of Textile Engineering, Lowell (Mass.) Textile Institute.

> *"Doubling exercises a great influence upon the regularity of the material; and it is quite clear that the general irregularities due to unevenness of the finisher scutcher lap will tend to be smoothed out by this operation, as a thick-place in one lot of material will frequently compensate for a thin-place in another lot. But when, as in all these machines, the doubling is accompanied by drafting so as either to reduce or keep constant the number of fibres in the cross-section, the question arises whether, in short lengths of the materials, any advantage derived by doubling might be offset by the irregularity produced by drafting."*

The purpose of this report is to present and discuss the results of actual observations of the effect of doubling on

(*a*) number irregularity,
(*b*) variation within short lengths.

The observations were made in connection with a study made by the writer and reported under the title of "The Irregularity of Card Sliver, Drawing Sliver, Roving, and Yarn for 22s, 28s, and 36s Counts Made from 1 1/16 Inch Delta Cotton."[2] Portions of the previous report pertinent to this discussion are briefly reproduced in this report.

The Material and Its Manufacture

The cotton used in this study was 1 1/16 Inch Delta, strict middling and middling grades mixed, in the form of single-process picker laps. From them 22s, 28s, and 36s warp yarns were produced using customary organizations.

In order to reduce factors causing variation to a minimum, one and the same delivery was used at each process for all tests. A test and check test were made in each case.

Sampling Procedure

Beginning with the card sliver, 6-inch lengths were cut from each of the strands throughout the yarn manufacturing process as indicated in Table I, using a method of stratified sampling," that is, the taking of a number of successive lengths from spots selected at random. Wherever doubling was employed, the specimens from each of the doubled strands were taken from corresponding positions. This relation of position was maintained as the individual 6-inch lengths were weighed and their weights recorded. The number of strands fed to the machines, the number of spots selected at random, the number of specimens cut at each spot, and the total number of specimens are shown in Table I. This applies for the tests and check tests for each of the three yarn counts.

Before being weighed, the individual specimens were thoroughly conditioned in an automatically controlled atmosphere of 65% relative humidity.

TABLE I

Sampling Data

Material	Doubling	Spots from each strand	Specimens from each spot	Total specimens
Card sliver fed to first drawing	6	4	20	480
First drawing sliver fed to second drawing	6	4	10	240
Second drawing sliver	—	24	10	240
Slubber roving fed to intermediate	2	12	10	240
Intermediate roving fed to fine frame	2	12	10	240
Fine frame roving fed to spinning	2	12	10	240

Effect of Doubling Upon Number Irregularity

The effect of doubling upon number irregularity is best shown where the number of strands doubled is large. For this reason the slivers were chosen for illustrations rather than the rovings.

The means of the weights of the 6-inch lengths of card, first drawing, and second drawing sliver were computed for each spot, each sliver, and each mass. Typical mean values were plotted graphically in Chart 1. Here it may be seen that the means of the spot samples of card sliver are scattered rather widely; those for the first drawing to a lesser degree, and those for the second drawing comparatively little.

Considering the means of the sliver samples, it may be observed that those for the card sliver have the greatest divergence among themselves; those for the first drawing are fairly uniform, and those for the second drawing are very uniform.

The spread of the spot means and the sliver means from the mass mean for the first drawing slivers shows the extent to which the very variable condition of the card sliver has been changed to a fairly uniform condition after the six slivers have been doubled and drawn into first drawing sliver. It should be kept in mind that the first drawing sliver is composed equally of the six card slivers.

The close proximity of the spot and sliver means to the mass mean is much better for the second drawing than for the first drawing. Thus, by a further doubling of six, the uniformity has again been increased.

This data very clearly shows that even for lengths as short as 6-ins. the evening effect of doubling on number irregularity is very pronounced.

The Effect of Doubling Upon Irregularity Within Short Lengths

In the discussion which follows, the coefficient of variation of 6-inch lengths has been used as the measure of irregularity.

In order to observe the effect of doubling upon irregularity within short lengths, it was first necessary to determine the coefficients of variation of the material to be doubled. Each strand, therefore, which was fed to a process where doubling occurred, has been treated as a separate universe or mass and analyzed as such. For convenience the results of this analysis are hereinafter referred to as the "before doubling" variation.

It will be obvious that the coefficients of variation as computed by the mass method are not in themselves, however, a measure of the variability of the doubled material. For example, when six card slivers are fed to the first drawing frame, the single specimen or unit of entering material is composed of the six 6-inch lengths of sliver which lay beside each other when sampling occurred, and which would have gone into the machine together in the form of a sheet or lap. It was, therefore, necessary to combine the weights of the six corresponding 6-inch lengths into a unit, and then to determine the variability of these units. For convenience the results of this method of analysis are hereinafter referred to as the "after doubling" variation.

Since the card and the first drawing slivers were doubled six times it was found possible to compute from the weight data four more illustrations of the effect of doubling by mathematically combining the strands as follows: namely, 12, 123, 1234, and 12345. For each of these combinations the coefficient of variation was determined for both "before doubling" and "after doubling."

In analyzing data by either method, the weights of 6-inch units were arranged in a frequency distribution and computations made of the mean, standard deviation of the mean, and coefficient of variation. The results of these computations are shown in Table II for sliver and in Table III for roving. The means of the weights, expressed in grams, of the 6-inch lengths of the single strands and their coefficients of variation are given, respectively, on the first two lines of the results for each test. The "before doubling" coefficients of variation for the combinations are given on the third line, the number combined agreeing with the strand number heading the column. For instance, in the column for Sliver 3, Table II, Line 3, the coefficient of variation is for Slivers 1, 2, and 3 combined; in Column 4, for the combination of Slivers 1, 2, 3, and 4; and in like manner for the others. The coefficients of variation for "after doubling" are given on Lines 4, the doubling agreeing with the combinations for "before doubling."

In the case of sliver, as examination of Table II shows that the doubling of two strands, with one exception * in eight cases, produces a resultant strand which is more uniform than the component single slivers, and in every case is more even than the combined strands.

In the case of roving, an examination of Table III shows that the doubling of two strands in every instance produces a resultant strand which is more uniform than the component single strands and the combined strands as well.

It might be presumed that as the number of doublings is increased beyond two, the coefficient of variation of the resultant strand would continue to decrease. An examination of Table II shows that there is a general trend from a higher to a lower value, but it is not always consistently so. Doublings of three do not always give results which are lower than doublings of two. Likewise, doublings of four do not always yield lower coefficients of variation than do doublings of three, and so on.

Two factors influence the deviation from the expected trend: first, the character of the frequency distributions of the weights for the individual strands; second, the probability of the heavier lengths being doubled with proportionately lighter lengths.

* See * in Table II.

TABLE II

Coefficients of variation for the single strands of sliver and the resultant combined strands and doubled strands.

TEST	LINE	VALUE	Sliver Number or Doublings 1	2	3	4	5	6
CARD SLIVER:								
22s	1	Individual Sliver Mean-Grams	0.5534	0.5701	0.5416	0.5586	0.5623	0.5736
	2	" " Coef.of Var.%	4.75	5.26	5.98	6.95	5.55	8.04
	3	Before Doubling " " "		5.37	5.77	6.10	5.99	6.48
	4	After Doubling " " "		3.16	2.62	2.74	2.66	2.95
	5	" " (P) " " "		3.79	3.33	3.05	2.68	2.65
22s Check	1	Individual Sliver Mean-Grams	0.5430	0.5696	0.5550	0.5481	0.5396	0.5580
	2	" " Coef. of Var.%	7.15	6.27	6.27	6.62	6.49	5.66
	3	Before Doubling " " "		7.06	7.21	7.08	7.01	6.68
	4	After Doubling " " "		3.68	3.17	3.41	3.40	3.20
	5	" " (P) " " "		4.99	4.16	3.54	3.13	2.73
28s	1	Individual Sliver Mean-Grams	0.5480	0.5485	0.5641	0.5417	0.5660	0.5819
	2	" " Coef.of Var.%	7.04	5.79	8.00	7.14	6.12	9.35
	3	Before Doubling " " "		6.44	7.15	7.21	7.08	7.81
	4	After Doubling " " "		4.43	3.87	3.95	2.98	2.98
	5	" " (P) " " "		4.55	4.13	3.60	3.17	3.19
28s Check	1	Individual Sliver Mean-Grams	0.6270	0.6169	0.5972	0.6232	0.5681	0.5973
	2	" " Coef. of Var.%	10.04	6.99	7.54	10.33	5.15	16.15
	3	Before Doubling " " "		8.78	8.67	9.10	9.03	10.54
	4	After Doubling " " "		4.82	5.23	5.93	5.15	4.67
	5	" " (P) " " "		6.21	5.01	4.55	4.04	4.30
FIRST DRAWING SLIVER								
22s	1	Individual Sliver Mean-Grams	0.5418	0.5488	0.5520	0.5522	0.5478	0.5445
	2	" " Coef. of Var.%	2.95	4.08	4.87	4.64	3.67	3.21
	3	Before Doubling " " "		3.63	4.13	4.23	4.16	4.03
	4	After Doubling " " "		2.28	2.45	1.94	1.43	1.52
	5	" " (P)		2.57	2.38	2.12	1.86	1.65
22s Check	1	Individual Sliver Mean-Grams	0.5590	0.5435	0.5363	0.5337	0.5320	0.5270
	2	" " Coef. of Var.%	4.79	3.15	3.13	2.42	2.56	4.63
	3	Before Doubling " " "		4.32	4.17	3.81	3.96	3.95
	4	After Doubling " " "		3.28*	2.79	2.10	1.88	1.29
	5	" " (P) " " "		3.05	2.41	1.90	1.77	1.61
28s	1	Individual Sliver Mean-Grams	0.5418	0.5190	0.5323	0.5420	0.5170	0.5407
	2	" " Coef.of Var.%	4.18	3.26	3.51	4.43	2.42	5.71
	3	Before Doubling " " "		4.34	4.09	4.18	4.15	4.49
	4	After Doubling " " "		2.74	1.96	1.68	1.56	1.48
	5	" " (P) " " "		3.07	2.36	2.09	1.86	1.83
28s Check	1	Individual Sliver Mean-Grams	0.5968	0.5647	0.5860	0.6065	0.6080	0.5845
	2	" " Coef.of Var.%	4.66	2.69	3.12	2.77	4.77	3.01
	3	Before Doubling " " "		4.73	4.27	4.32	4.61	4.42
	4	After Doubling " " "		2.11	1.94	1.92	2.21	2.05
	5	" " (P) " " "		3.34	2.47	2.16	2.06	1.80

To illustrate the first influence, Chart 2 has been prepared from the data for the first drawing sliver of the 22s Test. The graphs on the left of this chart represent the frequency distributions for the weights of 6-inch lengths of the respective individual slivers. Those on the right represent the frequency distributions of the resultant doubled strands. Also, the mean weights, the standard deviations, and the coefficients of variation are

shown for each distribution. It should be noticed that the scale index of the abscissa for the frequency distributions of the doubled strands is one-half that for the single strands. Also, it should be observed, the mean weight for a doubled strand is practically the sum of the mean weights of the component strands, and that successive plots are really at positions further along the horizontal axis.

Now, if it is remembered that the coefficient of variation is the ratio of the standard deviation to the mean, the explanation of this inconsistency

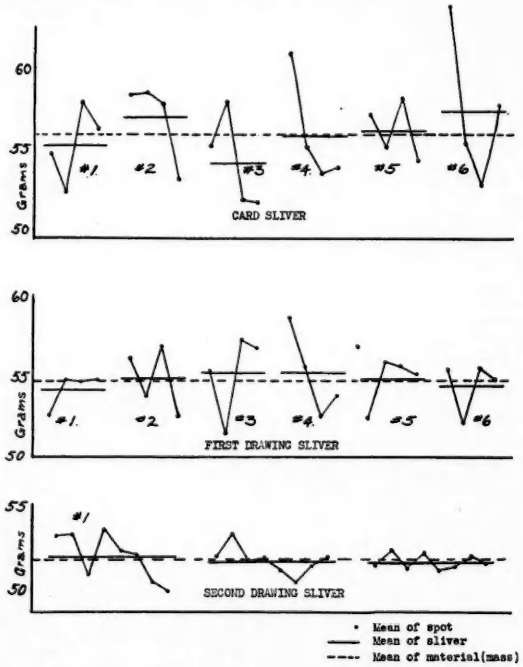

CHART 1. Irregularity of Sliver Shown by Weights of 6-inch Lengths.

is clear. From Chart 2 it will be seen that the mean or denominator of the fraction for the doubled strands increases in a 2, 3, 4, 5, and 6 order, whereas the standard deviation increases or decreases according to the character of the distributions. Thus when Sliver 5 with a standard deviation of 0.0201 grams is doubled with the doubled four strands with a standard deviation of 0.0426 grams, the result is a smaller standard deviation for the doubling of five, namely, 0.0393 grams. In the next instance, however, when Sliver 6 with a standard deviation of 0.0175 grams is doubled with the five doubled strands, the result is a larger standard deviation for the doubling of six, namely, 0.0499 grams.

Table III

Coefficients of variation for the single strands of roving and the resultant combined and doubled strands.

TEST:	LINE:	VALUE			SLUBBER (1) 1	SLUBBER (1) 2	INTERMEDIATE 1	INTERMEDIATE 2	FINE FRAME 1	FINE FRAME 2	SLUBBER (2) 1	SLUBBER (2) 2
22s	1	Individual Strand	Mean-Grams	0.1360	0.1348		0.0569	0.0553	0.0202	0.0199	0.1328	0.1354
	2	" "	Coef.of Var.%	7.65	7.95		7.21	7.41	5.94	7.54	8.28	8.64
	3	Before Doubling	" "	"	7.83			7.47		6.64		8.57
	4	After Doubling	" "	"	5.41			5.17		4.91		5.99
	5	" " (P)	" "	"	5.54			5.28		4.70		6.06
22s	1	Individual Strand	Mean-Grams	0.1341	0.1338		0.0572	0.0550	0.0201	0.0209	0.1314	0.1312
Check	2	" "	Coef. of Var.%	9.40	9.57		7.87	7.82	6.97	7.18	10.35	7.70
	3	Before Doubling	" "	"	9.48			8.20		7.47		9.90
	4	After Doubling	" "	"	6.82			5.61		4.73		6.28
	5	" " (P)	" "	"	6.70			5.80		5.28		7.00
28s	1	Individual Strand	Mean-Grams	0.1261	0.1290		0.0521	0.0510	0.0167	0.0162	0.1228	0.1235
	2	" "	Coef. of Var.%	8.23	9.82		7.66	7.65	8.20	6.85	7.33	7.43
	3	Before Doubling	" "	"	9.83			7.71		7.61		7.39
	4	After "	" "	"	6.85			5.51		5.56		5.35
	5	" " (P)	" "	"	6.63			5.45		5.38		5.23
28s	1	Individual Strand	Mean-Grams	0.1275	0.1260		0.0503	0.0507	0.0153	0.0153	0.1266	0.1246
Check	2	" "	Coef.of Var.%	7.45	6.67		6.94	6.31	7.84	6.54	7.66	7.38
	3	Before Doubling	" "	"	7.10			6.73		7.26		7.56
	4	After Doubling	" "	"	5.20			4.55		6.10		5.68
	5	" " (P)	" "	"	5.02			4.76		5.13		5.35
36s	1	Individual Strand	Mean-Grams	0.1148	0.1122		0.0445	0.0437	0.0141	0.0144	0.1121	0.1126
	2	" "	Coef.of Var.%	8.62	8.38		7.64	8.24	5.67	6.94	9.55	8.17
	3	Before Doubling	" "	"	8.48			7.90		6.47		8.90
	4	After Doubling	" "	"	5.81			6.01		4.35		6.22
	5	" " (P)	" "	"	6.00			5.59		4.58		6.29
36s	1	Individual Strand	Mean-Grams	0.1144	0.1163		0.0451	0.0455	0.0142	0.0146	0.1146	0.1137
Check	2	" "	Coef.of Var.%	10.05	9.46		8.21	8.79	8.45	8.22	9.42	10.03
	3	Before Doubling	" "	"	9.79			8.61		8.49		9.73
	4	After Doubling			6.66			6.85		5.92		6.38
	5	" " (P)			6.92			6.09		6.00		6.88

(1) Slubber roving fed to intermediate for regular-draft spinning.
(2) Slubber roving fed to intermediate for long-draft spinning.

It may be expected according to the theory of probability that the coefficient of variation for a doubled strand is equal to the "before doubling" coefficient of variation divided by the square-root of the number

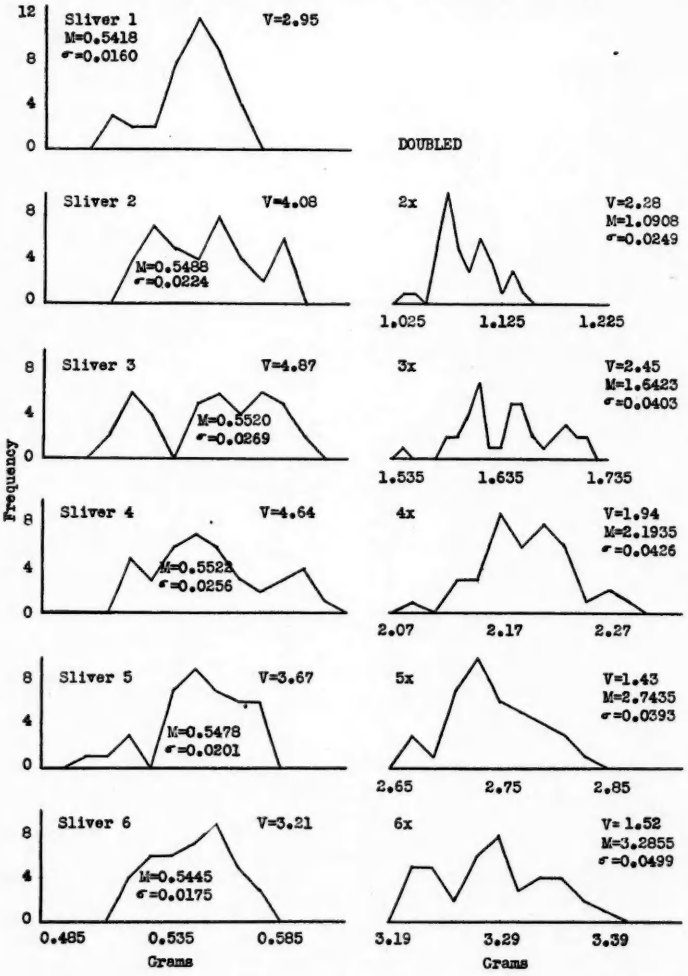

CHART 2. Frequency Distributions of Weights in Grams of 6-inch Lengths of Sliver.

of doublings. Thus, in the fifth line of the data (indicated by the letter "P") for each test in Tables 2 and 3 are given values which are the results of dividing the coefficients shown on the third lines by the square-root of the doublings.

Uncorrected and corrected [3] coefficients of correlation between the actual and expected "P"—after—doubling coefficients of variation for the data in Table II are as follows:

	Uncorrected	Corrected *
For 8 instances, doubling of 2,	+ 0.875	+ 0.853
" " " " " 3,	+ 0.908	+ 0.892
" " " " " 4,	+ 0.964	+ 0.952
" " " " " 5,	+ 0.957	+ 0.950
" " " " " 6,	+ 0.975	+ 0.971
For all instances of doubling,	+ 0.877	+ 0.873

* Corrected for small number of observations.

For the roving data, shown in Table III, the coefficient of correlation between the actual and expected "P" results for the 24 cases with doublings of 2 is + 0.857 uncorrected, and + 0.850 corrected.

Further, for 32 instances of doubling, as given in the original data [3] the coefficient of correlation between the actual and expected results is + 0.975. Using the averages for each of the five classes of material as shown in Table IV, much better correlation, as would be expected, is indicated.

TABLE IV

Average coefficients of variation for different materials

Class of Material	Doubling	Coefficient of Variation		
		Before Doubling	After Doubling	
			Actual	Expected
Card Sliver	6	7.88	3.45	3.22
First Drawing Sliver	6	4.22	1.58	1.72
Slubber Roving	2	8.68	6.05	6.14
Intermediate Roving	2	7.77	5.62	5.49
Fine Frame Roving	2	7.32	5.26	5.18
		Average	4.35	4.39

The difference between averages for the actual and expected coefficients of variation for "after doubling" is 0.04%. The correlation for the five pairs of values is: uncorrected, + 0.9949; and corrected for small numbers of observations it is + 0.9932.

Thus, actual results indicate a decrease in irregularity (measured over short lengths) after doubling. The actual results show good correlations with expected results based upon a theory that variability diminishes as the reciprocal of the square root of the doublings.

The writer is greatly indebted to Prof. Ball and to Mr. H. P. Gurney for many helpful suggestions.

References

(1) Turner, A. James. The Effect of Using Unbalanced Drafts. *Indian Central Cotton Committee Technological Laboratory Bulletin*, No. 15, June, 1928, Appendix, P. 24.

(2) Lee, R. L., Jr. A Critical Study of Cotton Manufacturing Processes. *Tex. Rsch.*, Vol. V, No. 4, Feb. 1935, P. 167–83.

(3) Ezekiel, M. "Methods of Correlation Analysis," P. 121 (Formula 25). John Wiley and Sons, New York, N. Y. 1930.

(*Continued from P. 240.*)

Seriplane testing of silk for evenness is to be correlated with the physical characteristics of the corresponding yarns by the Shirley Institute of the British Cotton Industry Research Association.

* * *

"Slipnaught Finish" for filament and spun rayon fabrics, and mixed constructions using synthetic fibres, has been developed and patented by the Aspinook Co., Jewett City, Conn. Slipping of warp and filling threads, and fabric distortion due thereto are eliminated.

* * *

Mildew-proof fire hose of Raybestos-Manhattan Co., Inc., is said to be the result of treatment with the radioactive salts of certain rare earth metals, developed by the research staff of its Manhattan Rubber Manufacturing Division. Fire hose thus treated is moisture repellent, rot- and freeze-proof, and preserves strength and flexibility indefinitely, according to *The Technology Review*.

* * *

Dyes vary enormously in their ability to resist fading in sunlight, and while some dyes increase the tendency of cellulose to disintegrate on prolonged exposure to light others exert a definite protective action. If the reason *why* dyes behave so differently could be found, a great step forward would have been made, and intensive research by the British Cotton Industry Research Association is in progress in the hope of supplying the answer to this question. *Tex. Mfr.*

* * *

Sheep Skin Transplanting.—In an effort to discover whether the difference in the fibre properties of wool grown on the hind quarters and shoulders of sheep is due to heredity or nutrition, Prof. J. F. Wilson, College of Agriculture, University of California, is transplanting the animal's skin from one part to the other and studying the results.

* * *

Wool Hairiness.—The Massey Agricultural College in co-operation with New Zealand wool growers is systematically testing stud sheep for hairiness and kempiness of their fleeces, and then culling out rams whose fleeces are not satisfactory in this respect. Followed by careful breeding this is expected to materially improve the quality of New Zealand wools.

* * *

Dyed Asbestos Fabrics are being produced in England in a variety of so-called fast colors with a new synthetic dye, according to a report credited to the American Institute of Mining and Metallurgical Engineers. In addition to the usual asbestos fabrics, aprons, rugs and table covers are mentioned.

Abstracts

Committee on Abstracts and Bibliography:
E. R. Schwarz, Chm., M. W. Weiss, Dr. I. J. Saxl, C. H. Clark.

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Address C. H. Clark, Sec., 65 Franklin St., Boston, Mass.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Breaking up Wool into its Histological Components. (German.) R. Haller. *Mell. Textilber.*, 1936, P. 645.

The wool was broken up into its components of cortex cells, scales, and cementing substance by treatment with concentrated ammonia. The cementing substance is said to be an albuminoid free from sulphur which has been called lanain. Denatured lanain can be made soluble again by the action of concentrated ammonia and can be coagulated once more from that solution. The author has succeeded in isolating unknown crystalline substance from wool which is insoluble in water, alcohol and ether and has a melting point of 110° C. It was not possible to break up dyed wool by means of the concentrated ammonia. (S)

Chemical Constitution of Raw Silk. I–III. Imakichi Toyoda. *J. Chem. Soc. Japan*, 1936, V. 57, P. 985–9, 1110–27; *C. A.*, 1937, V. 31, Col. 262, 545.

A review and discussion. (W)

Retting of Flax: L. I. R. A. Duplex. *Tex. Mfr.*, Oct. 1936, P. 381.

The British Linen Industry Research Association has evolved a patented method of giving a double ret without extra labor and cost. This flax is given the double retting in tanks without the removal of the straw or intermediate drying. (C)

SILK FIBROIN: LATTICE CHANGE OF—DURING VACUUM DRYING. Y. Matsunaga. *Naturwiss.*, 1936, V. 24, P. 446–7.

Drying of fibroin in a vacuum camera and study with Cu X-rays indicates that the lattice const. of completely dry material is smaller; hence intramicellar swelling occurs. The const. of normal fibroin equals that of water-soaked fibroin; hence the swelling of soaked fibroin is an intermicellar one. (From *C. A.*, 1937, V. 31, Col. 262.) (W)

STRUCTURE OF PROTEINS. D. M. Wrinch. *Nature*, 1936, V. 138, P. 651–2; *J. Soc. Dyers Col.*, Dec. 1936, P. 471. (C)

SWELLING OF VISCOSE RAYON P. Thivet. *Rusta*, 1936, V. 11, P. 401–2; *C. A.*, 1936, V. 30, Col. 8627.

WOOL: INFLUENCE OF VARIOUS FACTORS UPON THE GROWTH AND QUALITY OF FINE—AS OBTAINED FROM MERINO SHEEP. D. S. Bell, D. A. Spencer and J. I. Hardy. *Ohio Agr. Exp. Sta. Bull.* 571, P. 3–57, 1936; *C. A.*, 1936, V. 30, Col. 8628.

A higher percentage of grease content is not the factor that affords protection to a growing fleece from weathering, due to climatic factors. The main factors involved seem to be length of staple and density of fibre. American merino fleeces show marked variations in fibre diams. (W)

WOOL: HALOGENATION AND ALLWÖRDEN'S REACTION. A. Baron. *Rev. gen. mat. col.*, 1936, V. 40, P. 171–2; *J. T. I.*, Aug. 1936, P. A354.

In Allwörden's reaction it is necessary to distinguish between the action of chlorine on keratin and on elasticum. The biuret reaction shows the solubilizing action of chlorine on wool. Various references are given. (C)

MOLECULAR WEIGHTS OF CELLULOSES: A SURVEY OF RECENT WORK. S. M. Neale. *Chem. and Ind.*, 1936, V. 55, P. 603–5; *J. Soc. Dyers Col.*, Nov. 1936, P. 442. (C)

TENACITY OF JUTE. J. B. Martineau. *Rev. Gén. Tein. Imp. Blanch. App.*, 1936, V. 14, P. 491–7; *J. Soc. Dyers Col.*, Nov. 1936, P. 408. (C)

II. YARNS AND FABRICS

ACETATE YARNS: BRIGHT AND DULL. Anon. *Am. W. & C. Rptr.*, Jan. 7, 1937, P. 11–2, 39.

Discusses their elongation and tensile strength under various hygroscopic conditions and shows need of more exact information. (C)

BALLOONLESS RING SPINNING. H. R. Mauersberger. *Rayon Tex. Mo.*, Dec. 1936, P. 57–8.

Describes and illustrates the so-called "balloonless spindle" (German patents Nos. 597,022 and 634,059). (C)

BAST-FIBRE WOOL: MANUFACTURE AND APPLICATIONS OF. A. Jaumann. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 409–11; *C. A.*, 1936, V. 30, Col. 6570.

Various chem. and mech. problems are reviewed dealing with the manuf. and uses of this product. (W)

BAST FIBRES: NEW METHODS IN TECHNOLOGY OF. W. Bratkowski. *Mell. Textilber.*, 1937, No. 1, P. 10.

The author criticizes the methods of the technology of bast fibres hitherto adopted and comes to the conclusion that they are too expensive compared with the methods applied to other fibres. He proposes a new cottonizing process in which the raw material must be clean and openers and cards are eliminated. (C)

BORAX–BORIC ACID FIREPROOFING AGENTS: EFFICIENCY. R. Clarence. *Tiba*, 1936, V. 14, P. 405–9; *C. A.*, 1936, V. 30, Col. 7350.

Tests on the efficiency of borax-boric acid mixtures for fireproofing cotton fabrics are described. *Burning tests.* A fabric was steeped in solutions to give 2, 4, 6, 8, 10 and 15% of the fireproofing agent, on the dry weight. Each of these weighings was secured with borax or boric acid alone and with mixtures of the two varying by 10% steps (10–90, 20–80, etc.). Satisfactory resistance in the burning test described was secured with the 6% weighting of boric acid 40, borax 60; with the 8% weighting of the 30–70, 40–60, and 50–50 mixtures; and with the 10 and 15% weightings of the five mixtures 30–70 to 70–30. *Strength tests.* The same fabric was impregnated with 4, 8 or 15% of boric acid or borax or the 40–60 mixture and the strength measured after heating for 4 hours at 100, 120, 140–200° C. Loss of strength was already observed at 120°, but the plain fabric was not tendered at 140°. The mixture caused less tendering than the acid alone. *Discoloration tests.* The fabric is more darkly colored after heating at 200° when impregnated with borax alone than when boric acid or the mixture is used. The mixture, therefore, is preferred because of the compromise indicated in the strength and discoloration tests. (From *J. T. I.*, Sept. 1936, P. A434.) (C)

CAKES AS YARN SUPPLY FOR VISCOSE CRÊPE. Jos. Brandwood. *Silk & Rayon*, 1936, V. 10, P. 186, 188–9.

The advantages of using cake yarn for crêping are a lower price for the flat yarn, reduction of labor costs in sizing, winding and twisting, the elimination of the back-winding process for certain purposes, and the lowering of waste. The sole disadvantage is the prolonged drying period necessary for the cake. (From *C. A.*, 1936, V. 30, Col. 6950.) (W)

COMPRESSIBILITY AND SOFTNESS OF TEXTILES. III. Prof. Sommer. *Mell. Textilber.*, 1936, No. 10, P. 786.

Conclusion of a series of articles defining and discussing the factors and properties involved. (C)

COTTON YARN CONDITIONING. J. Klinck. *Cotton*, 1936, No. 4, P. 62; *Rayon Tex. Mo.*, Nov. 1936, P. 88.

The author gives a brief description of the hot and cold methods of conditioning cotton weft yarns for the purpose of setting the twist. The advantages of cold processes using penetrants are pointed out. (C)

DRY FINISHING WOOL POPLIN FABRICS: SOME COMMON PROCESSING FAULTS IN—AND HOW TO AVOID THEM. G. L. Atkinson. *Tex. Merc.*, 1935, V. 94, No. 2453, P. 271; *C. A.*, 1936, V. 30, Col. 6570. (W)

DRYING OF STAPLE RAYON: CONTINUOUS. F. K. Howell. *Am. W. & C. Rptr.*, Nov. 19, 1936, P. 13–4, 28; *Tex. Wld.*, Dec. 1936, P. 83; *Rayon Tex. Mo.*, 1937, Jan., P. 75–6; Feb., P. 65–6.

Paper read at a recent meeting of the Textile Division of the A. S. M. E. Describes recent foreign developments. (C)

FIBRES: DECREASE IN VALUE OF—THROUGH OVERHEATING. *Spinner und Weber*, Apr. 17, 1936, P. 7–9.

Examples of faults in textile materials that have been traced to the action of heat are briefly described and the effect of high temperatures on wool, silk, cotton, rayons and other textile materials are discussed. Processes in which over-heating is liable to occur are indicated, and data showing the influence of dry and moist heat on the breaking load and extension of cellulose acetate rayon are given. (From *Cotton Literature*, Jan. 1937.) (C)

DAMAGING OF DRYING FELTS UPON PAPER MACHINES AND PROCESSES FOR THE REDUCTION OF WEAR. Ruth Werner. *Beiheft Z. Ver. Deut. Chem.* No. 23, *Angew. Chem.*, 1936, V. 49, P. 382–4; *C. A.*, V. 30, Col. 5785; *Paper Trade J.*, Jan. 7, 1937, P. 48.

The wear on paper machine wool felts is due to free sulphuric acid. The sulphate ions found in the felt result partly from the paper sizing process. For the most part, however, they consist of acid which was formed by oxidation during the steaming process from the sulphur of the wool. The removal of the sulphur atoms results in voids in the wool lattice which in turn give increasing damaging. This sulphuric acid remains bound as a form of wool sulphate with the organic substance. The introduction of an ammonia-air mixture, as carried out continuously in practice, does not neutralize the oxidatively formed acid and no further protection than is obtainable at present can be reached with this process. Increased ammonia concentration results in an increasing damage to the wool. In the case of cotton, the protection given by dilute ammonia must be almost complete, as the formation of sulphuric acid by oxidation is not possible in this instance. The decrease in strength is about the same for wool and cotton, but the tensile properties of cotton are somewhat better than those of wool, which has been aged correspondingly by oxidation. (C)

HANDLING PROCESSES. G. L. Atkinson. *Am. Dye. Rptr.*, Nov. 16, 1936, P. 631–3.

Defines the processes that affect handle of a finished fabric and how they may affect it properly or improperly. (C)

HEAT RETAINING PROPERTIES OF CLOTHING COMPUTED ON A PHYSIOLOGICAL BASIS. II. T. C. Angus. J. T. I., Nov. 1936, P. T273–84.

The paper is the completion of an earlier work published in *J. T. I.*, 1935, *26*, T225–40, outlining the principles of a new method for determining the (dry) heat retaining properties of clothing materials, singly, or as worn in combination with more than one garment. Results are expressed as percentages of a complete stoppage of heat flow, such as would result from a reduction of temperature gradient to zero. The "Tight" and "Loose" parts of the clothing are separately evaluated and the effects of this physical difference are compared, in still air and in a wind of about five miles per hour. A table gives the percentage insulations found for a

number of different combinations of clothing materials, as likely to be worn. It was found that typical women's clothes are nearly as "warm" as men's in still air, but that the women's clothes gave considerably less protection against draughts. The increasing insulation afforded by the successive addition of similar layers of flannel has been measured. The experimental procedure is described in detail and the effects of changes of tension in the samples and of the relative humidity of the air are discussed. (C)

HIGH TWIST: PROBLEM OF. R. Brandt. *Mell. Textilber.*, 1936, No. 10, P. 783.

The author deals with the question of the twist imparted to crêpe yarns and examines the effects which the size, atmospheric humidity, heat, and other properties of the material have upon the twist. He also deals with the problem of imparting the twist to the yarn in one or two stages. The nature of the sizing is also a factor of great importance. The strength of the thread can be improved by suitable preparation or the torsion tension can be lowered by means of softeners. (C)

IRONING AS A FACTOR IN THE DETERIORATION OF COTTON FABRICS. Ruth E. Elmquist and K. Melvina Downey. *Rayon Tex. Mo.*, Dec. 1936, P. 68–70, 74. (C)

JUTE: EFFECT OF—ON SPINNING VALUE OF COTTON. W. Lawrence Balls and H. A. Hancock. *Internatl. Cotton Bulletin*, Oct. 1936, P. 97–8. (C)

MOTHS: THEIR HABITS AND CONTROL. Samuel C. Prescott. *Am. Dye. Rptr.*, Jan. 11, 1937, P. 9–10, 18.

Paper presented at meeting, Northern N. E. Section, A. A. T. C. C., Nov. 6, 1936. (C)

MOIRÉ EFFECTS ON RAYON FABRICS. G. S. Ranshaw. *Silk & Rayon*, 1936, V. 10, P. 464–6; *C. A.*, 1936, V. 30, Col. 6571. (W)

POROUS WATERPROOFING OF RAYON GARMENTS. G. S. Ranshaw. *Silk & Rayon*, 1936, V. 10, P. 113–4.

The advantages of one-bath waterproofing processes and the use of Waxol W for viscose and acetate rayons are described. Waterproof tests show that there is no relation between permeability to air and H_2O. (From *C. A.*, 1936, V. 30, Col. 6571.) (W)

RAYON AND RECENT DEVELOPMENTS. Chas. S. Venable. *Am. Dye. Rptr.*, Jan. 11, 1937, P. 6–8; *Tex. Bull.*, Jan. 28, 1937, P. 4–6.

Paper presented at meeting, Philadelphia Section, A. A. T. C. C., Nov. 20, 1936. (C)

RAYON-FABRIC SCOURING DIFFICULTIES. H. Roche. *Tex. Mfr.*, 1936, V. 62, P. 314; *C. A.*, 1936, V. 30, Col. 6951. (W)

RING-SPINNING WITHOUT BALLOONING. Walter Frenzel. *Mell. Textilber.*, 1936, No. 11, P. 849.

Describes the so-called balloonless spindle of Willy Freund, Chemnitz. A cap the size of a spindle head carries pins which cause the thread to

apply itself spirally about the upper end of the spindle. A number of illustrations serve to explain the details of the design of the spindle. (C)

SHRINKAGE OF STAPLE FIBRE-COTTON FABRICS. H. Friedmann. *Mtsh. S. u. Ksts.*, 1936, P. 177; *Rayon Tex. Mo.*, Dec. 1936, P. 84.

The author discusses the causes of the shrinking of fabrics on wetting and gives the results of test on staple fibre, cotton, and staple fibre-cotton mixture fabrics. These results are described in detail. (C)

SHRINKAGE: PROBLEM OF. F. Courtney Harwood, Director of Research to the British Launderers' Rsch. Assoc. *J. T. I.*, Sept. 1936, P. P333–44.

Pertains particularly to cotton, linen and wool goods, the causes of their shrinkage and present control methods. Points to probable modification of permissible shrinkage tolerances of British Launderers' Research Association to ± ¼ in., for both warp and filling, or ± 0.7% in either direction. (C)

SILK PROCESSING: RECENT PROGRESS IN. *Rev. gén. mat. color*, 1936, V. 40, P. 246–8; *C. A.*, 1936, V. 30, Col. 6570. (W)

SPUN RAYON: RESEARCH PROBLEMS IN FIELD OF. W. Weltzien. *Monatsh. Seide Kunstseide*, 1936, V. 41, P. 294–6, 298; *C. A.*, 1936, V. 30, Col. 6570. (W)

SPINNING OF HAIR YARN. Oswald Bernhard and Max Radlegger. *Mell. Textilber.*, 1937, No. 1, P. 25.

The article contains a survey of the whole process of spinning hair yarn. In connection therewith calculations are worked out and discussed for the course of operations of spinning both coarse as well as fine hair yarns. The article contains extensive calculations. (C)

SPINNING TEST STATION AT GIZA: PROGRESS REPORT ON. H. A. Hancock. *Internatl. Cotton Bulletin*, Oct. 1936, P. 95–6.

Sakel is now definitely vanishing from the Egyptian market, and the only question is how long the process will take. When this Federation holds its meeting in Cairo next year, the Ministry of Agriculture will show cottons which are from 5 to 10% stronger than the best Sakels that ever came out of Egypt, grade for grade, and there is no reason to think that the trade will be unable to obtain the high strength cotton to which they are accustomed, through the passing of the Sakel variety. (C)

SPUN RAYON AND ITS APPLICATION IN TEXTILE GOODS. H. Schreiterer. *Monatsch. Seide Kunstseide*, 1936, V. 41, P. 263–6; *C. A.*, 1936, V. 30, Col. 6571. (W)

SPUN RAYON YARNS: INFLUENCE OF AIR HUMIDITY ON. Walter Frenzel. *Monatsch. Seide Kunstseide*, 1936, V. 41, P. 266–7.

The tests described show that spun rayon yarn is greatly affected by air humidity and that it is advisable to keep the humidity const. not only during its weaving or knitting but also during storage. (From *C. A.*, 1936, V. 30, Col. 6571.) (W)

III. Chemical and Other Processing (Not Otherwise Classified)

Anthraquinone Dyes. R. Fraser Thomson. *J. Soc. Dyers Col.*, 1936, V. 52, P. 237–47; *C. A.*, 1936, V. 30, Col. 6566.

A brief historical survey of com. dyes derived from anthraquinone, and special consideration of a few sections of special interest, such as the benzanthrone derivs. and those of other homocyclic quinones. (W)

Artificial Fibres: Method of Judging the Relative Efficiencies of the Absorptive Properties of. K. M. Markuze. *Rekon. Tekstil. Prom.*, 1935, V. 14, No. 1, P. 40–5; through *Chem. Zentr.*, 1935, V. II, P. 2883; *C. A.*, 1936, V. 30, Col. 6567. (W)

Automatic Wool Dyeing. Co-ordinated Control System Doubles Output. Anon. *Rayon Tex. Mo.*, Dec. 1936, P. 78–9. (C)

Auxiliary Reagents in the Textile Industry. Louis Diserens. *Rev. gén. mat. color.*, 1936, V. 40, P. 225–40; *C. A.*, 1936, V. 30, Col. 3651, 6569. (W)

Azo Dyes: New. II. Al Mironescu and I. V. Nicolescu. *Bul. soc. chim. Romania*, 1935, V. 17, P. 293–6; *C. A.*, V. 28, Col. 121; V. 30, Col. 6947. (W)

Azo Dyes: Preparation of—Derived from Nitroanilines. Ugo Pelagatti and Gualtiero Ricci. *Ann. chim. applicata*, 1935, V. 25, P. 603–9; *C. A.*, 1936, V. 30, Col. 6565. (W)

Bleaching and Dyeing Rabbit Wool. F. S. Verdlandt. *Tex. Col.*, 1936, P. 448.

H_2O_2 is preferable to $NaHSO_3$ for bleaching Angora rabbit wool. A list of acid dyestuffs suitable for rabbit wool is given. (From *C. A.*, 1936, V. 30, Col. 6568.) (W)

Cellulose Acetate: Why Direct Dyes Color. *Am. Dye. Rptr.*, Sept. 7, 1936, P. 479–82.

Substantivity, or the ability of dyes to deposit directly upon cellulose is one of the most fundamental of the phenomena of direct dyeing. A new theory which seems to deserve special attention has its basis in the residual valency of unsaturated atom groups as the cause of substantivity. That is, in all direct dyes and substantive intermediates there are systems or chains consisting of a number of conjugated double bonds whose residual valency together with some affinity for auxochrome groups causes the attraction to cellulose. The probable correctness of this view has been demonstrated from typical direct dyes and intermediates but certain groups have been shown to interfere. The new theory can serve as a working hypothesis for the synthesis of improved dyes. This article is based mainly on the presentation of this new theory by E. Schirm in a paper "Ueber das Wesen der Substantivitaet" in the *Journal fuer praktische Chemie*, 1935, V. 144, P. 69, together with some data from the other references given. No pretense has been made of fully covering the literature on this subject. (C)

CELLULOSE FINISH: NEW. *Tex. Recdr.*, Dec. 6, 1936, P. 50.

Involves mercerization after treatment with a cuprammonium solution. (C)

CELLULOSE MATERIALS: FURTHER NOTES ON THE TENDERING AND FADING OF—ON EXPOSURE. J. I. M. Jones. *J. Soc. Dyers Col.*, 1936, V. 52, P. 285–99; *C. A.*, V. 17, P. 3421, V. 19, P. 1950, V. 30, Col. 7347. (W)

CELLULOSE MATERIALS: NEW METHOD FOR THE DETERMINATION OF SUBSTANTIVE DYES ON THE FIBRE AND THE ABSORPTIVE ABILITY OF. K. M. Markuze. *Rekon. Tekstil. Prom.*, 1934, V. 13, No. 12, P. 47–52; *C. A.*, 1936, V. 30, Col. 6567

The colorimetric detn. of the dye after extn. with a 10% pyridine soln. is reported. (W)

CHEMICAL AND TEXTILE-CHEMICAL INVESTIGATION OF TEXTILE ASSISTANTS AND DYES. F. Seidel and O. Engelfried. *Ber.*, 1936, V. 69, P. 2567–91; *J. Soc. Dyers Col.*, Jan. 1937, P. 33.

The relations between constitution, and the absorption and retention by the fibre of modern types of textile assistants containing long-chain alkyl radicals, have been investigated by determining the effect produced by introducing long-chain radicals into a number of aromatic compounds and dyes. (C)

CHEMISTRY OF SOME NEWER TEXTILE ASSISTANTS. A. J. Hall. *Am. Dye. Eptr.*, Oct. 19, 1936, P. 561–5. (C)

CHLORINE BLEACH: STUDIES ON. Part I. Egon Elöd and Franz Vogel. *Mell. Textilber.*, 1937, No. 1, P. 64. (C)

CHLORINE BLEACH LIQUORS: STABILITY OF. A. Foulon. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 991–2; *C. A.*, 1936, V. 30, Col. 6572. (W)

DYEING OF YARNS FOR CARPETS. Gerd Nitschke. *Monatschr. Textil-Ind.*, 1936, V. 51, P. 185–6; *C. A.*, 1936, V. 30, Col. 6948. (W)

DYEING PROPERTIES OF COTTON AND WOOL: NEW METHODS FOR MODIFYING THE. A. J. Hall. *Tex. Recdr.*, Sept. 6, 1936, P. 35–7. (C)

DYEING PIECE GOODS WITH ACID COLORS. S. Wouble. *Tex. Recdr.*, 1936, Nov. 6, P. 48; Dec. 6, P. 46. (C)

DULLING AGENTS: EXAMINATION OF MOST IMPORTANT. Alois Herzog. *Mell. Textilber.*, 1937, No. 1, P. 77.

Examples of the examination of the various dulling agents which nowadays play an important role in the rayon industry are discussed in detail. (C)

EVENNESS, PENETRATION AND STRIPPING OF VAT DYES. Robert Juge. *Tiba*, 1936, V. 14, P. 267–71; *C. A.*, 1936, V. 30, Col. 7347. (W)

FLAVINDULINE DERIVATIVES. II. K. Yamada and K. Oiwa. *J. Soc. Chem. Ind., Japan* 39, Suppl. binding, 1936, P. 207 (in German); *C. A.*, V. 29, Col. 4587; V. 30, Col. 6567. (W)

FUROLE DYES: FURTHER STUDIES ON THE. Ossian Aschan. *Finska Kemistamfundets Medd.*, 1935, V. 44, P. 62–70; *C. A.*, V. 29, Col. 1987; V. 30, Col. 6565. (W)

GLYCEROL VERSATILE AID IN SILK AND RAYON PROCESSING. Georgia Leffingwell. *Am. Silk Rayon J.*, 1936, V. 55, P. 19–20; *C. A.*, 1936, V. 30, Col. 6950. (W)

HYDROGEN ION CONCENTRATION: NEW APPLICATIONS OF THE CONTROL OF THE—IN TEXTILE FINISHING. John Muir. *Mell. Textilber.*, 1936, No. 10, P. 808.

The author deals exclusively with the application of the indicator method, because it is easier to use under ordinary working conditions than most of the potentiometric methods which are at disposal at the present moment. (C)

HYPOCHLORITE OXIDATION OF CELLULOSE IN THE PRESENCE OF A REDUCED VAT DYE. G. M. Nabar, F. Scholefield and H. A. Turner. *J. Soc. Dyers Col.*, Jan. 1937, P. 5–26.

The results set out showed two features of special interest. The first was the great acceleration of the oxidation of cellulose which was shown to occur in the presence of reduced vat dyes. This acceleration might account for some of the instances of severe tendering observed during the dyeing of these dyes, or when dyeings upon cellulose materials were subjected to chemical treatments or were exposed to the combined influence of light and air. Secondly, the close connection between the extent of the accelerated oxidation and the corresponding potential of the oxidizing agent might help in explaining the mechanism by which cellulose was oxidized. (C)

KIER ACCIDENTS: RULES DESIGNED TO PREVENT. C. H. S. Tupholme. *Am. Dye. Rptr.*, Sept. 7, 1936, P. 483–6, 495.

Recommendations of a government committee for the safety of operatives working in and about kiers made to the British Home Secretary. (C)

LOGWOOD DYES FOR WOOL: DON'T BE AFRAID OF—; THE SECRET OF SUCCESSFUL PROCESSING. Jacques Horrod. *Tex. Recdr.*, July 6, 1936, P. 43.

Complete soln. of the logwood ext. before entering the goods ensures successful dyeing. Oxalic acid or brown tartar gives the best results, but no excess of acid should be used. (From *C. A.*, 1936, V. 30, Col. 6947.) (W)

MATT RAYON: TITANIUM DIOXIDE AS A DELUSTRANT. C. L. Moore. *Rayon Tex. Mo.*, 1936, Nov., P. 57–8; Dec., P. 43–4. (C)

MUNSELL SYSTEM OF COLOR SPECIFICATION. Walter M. Scott. *Rayon Tex. Mo.*, 1936, Dec., P. 41–3.

NACCOLENE F., THE REVOLUTIONARY DRY CLEANER. O. M. Morgan. *Dyestuffs*, 1936, V. 34, P. 69–74; *C. A.*, 1936, V. 30, Col. 6573.

Naccolene F is a "sulfonated deriv. of long-chain hydrocarbons which possess remarkable stability toward all adverse chem. conditions encountered in dry-cleaning practice." (W)

METAPHOSPHATES. Kurt Lindner. *Mell. Textilber.*, 1936, No. 11, P. 861.

The author discusses the fundamental difference between the latest synthetic organic detergents (sulphonates of fatty alcohols and condensation products of fatty acids) and the water softening agents known as inorganic mataphosphates. He further examines the behavior of metaphosphate in the absence of soap, but in the presence of hardness forming salts, by measuring the turbidity of several series of concentrations. (C)

POISONING FROM DYESTUFFS. Otto Schulz. *Gasmaske*, 1936, V. 8, P. 79–81.

The poisonous properties of various dyes and pigments are discussed. In general well-defined cases of poisoning from dyes and pigments are comparatively infrequent and since the substitution of natural dyes by synthetic org. dyes skin effects occur more frequently than actual metallic poisoning or other systemic effects. Also the solvents used with dyes seem much more poisonous than the dyes themselves. (From *C. A.*, 1936, V. 30, Col. 6948.) (W)

PRINTING OF ACETATE FABRICS. H. P. Baumann. *Tex. Col.*, 1936, V. 58, P. 193–4.

The prepn. of anthraquinone dyes and the use of different types of dyes for printing acetate fabrics are discussed. Typical formulas are given. (From *C. A.*, 1936, V. 30, Col. 6569.) (W)

PRINTING PASTES: PREPARATION OF. G. Tagliani. *Am. Dye. Rptr.*, Oct. 19, 1936, P. 578–9. (C)

RAYON SIZING AND CRÊPEING. VI. G. E. Wilson. *Silk & Rayon*, 1936, V. 10, P. 458–60.

Methods and equipment for both hot and cold sizing of rayon yarns are described. (From *C. A.*, 1936, V. 30, Col. 6571.) (W)

REMOVAL OF LINSEED OIL FINISHES UPON ARTIFICIAL SILK WEAVES. Harry Schneider. *Monats. f. Seide u. Kunstseide*, 1934, V. 39, P. 376. (C)

REMOVAL OF SPOTS: NEW METHODS FOR. E. Meissner. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 1055–6; *C. A.*, 1936, V. 30, Col. 6951. (W)

SPUN RAYON: PROCESSING OF. Erich Quensell. *Monatsch. Seide Kunstseide*, 1936, V. 41, P. 274–7; *C. A.*, 1936, V. 30, Col. 6571.

Dyeing, bleaching and mercerizing of mixed fabrics of cotton and spun rayon. (W)

STABILIZERS FOR HYDROGEN PEROXIDE BLEACHES. J. Porzky. *Z. ges Textil-Ind.*, 1936, V, 39, P. 451–2; *C. A.*, 1936, V. 30, Col. 6951. (W)

STRIPPING COLORS. Karl Volz. *Mell. Textilber.*, 1936, No. 12, P. 940.

The precautions that are necessary to protect the fibres during the operation are explained and a number of methods which have proved to be practical for stripping various dyestuffs from different classes of fibrous materials are recommended and fully described. (C)

SUBSTANTIVITY OF A NUMBER OF TEXTILE ASSISTANTS. Otto Mecheels. *Mell. Textilber.*, 1937, No. 1, P. 103.

The substantivity of a textile assistant and therewith its more or less water-resistant adsorption by the fibres depends upon the direction and charge of the particles, the dispersity in the aqueous medium, the reaction of the liquor, the electrical charge of the textile material, and finally upon the temperature of the liquor. Assistants which are adsorbed molecularly by the fibres do not alter the softness, lustre, and handle of the goods. Softening, waterproofing, and scrooping agents must be present in the liquor in a coarsely disperse state. (C)

IV. RESEARCH METHODS AND APPARATUS

ABSORPTION OF DYES BY STAPLE FIBRE: QUANTITATIVE DETERMINATION OF. W. Weltzien and K. Schulze. *Seide u. Kunstseide*, 1936, V. 41, P. 142–49; *J. Soc. Dyers Col.*, Aug. 1936, P. 323.

The amount of dye absorbed by rayon staple fibre can be determined by the colorimetric examination of the used dyebath or of aqueous pyridine extracts of the dyed fibre. Details are given of the exact procedure, including the preliminary purification of the fibrous material and dye, preparation of the dye solutions, and standard procedure and apparatus for use in dyeing in the form of loose fibres or hanks, or simultaneously with other fibres. (C)

AUTOMATIC CONTROL IN THE TEXTILE INDUSTRY: USE AND APPLICATION OF. F. S. Ward and R. D. Cleveland. *Am. Dye. Rptr.*, Jan. 25, 1937, P. 30–3. (C)

BREAKING STRENGTH OF COTTON YARNS: DETERMINING. Mary Anna Grimes. *Tex. Bull.*, Jan. 21, 1937, P. 9–10; *Tex. Rsch.*, Jan. 1937, P. 145–8. (C)

COMPRESSIBILITY AND SOFTNESS OF TEXTILES. Prof. Sommer. *Mell. Textilber.*, 1936, P. 630, 786.

A review of certain processes notably those worked out by Eggert, G. Herzog and H. J. Henning are reviewed in some detail. It is stated that the process described by Herzog is especially well adapted for testing the filling qualities and elasticity of stuffing materials under repeated pressure while the process devised by Henning is intended to test the elasticity of tufts in pile fabrics and is based upon the measurement of the work expended in compressing them. Attention is drawn to *Mell. Textilber.*, 1934, P. 12. (S)

DURATION TESTING OF YARNS AND FATIGUE. (German.) K. Stirm and H. P. Zoeppritz. *Mell. Textilber.*, 1936, P. 555, 632.

A duration testing machine designed by the author is described in detail together with certain tests carried out by its use. When variable

tension was employed it was found that the strength properties of the yarn tested showed no signs of falling off owing to fatigue caused by the protracted strain. It was found, however, that some yarns gained in strength as a result of reasonable duration testing. Such tests had an injurious effect upon the stretching properties of the yarn. Work done on woolen cords showed that there was much less loss of elongation than in the case of cotton cords, but that otherwise the same principles applied.

The point of time at which breakage occurs is stated to depend mainly upon the extent of the strain to which the yarn is exposed. The greatest strain to which the material can be exposed without breaking is known as the working limit. In the case of textiles it is pointed out that this is of importance particularly for tire cords, belting, and similar materials. (S)

DISPERSION OF NATIVE AND HYDRATED CELLULOSE. A. Frey-Wyssling. *Helv. Chim. Acta*, 1936, V. 19, P. 900–14; *J. Soc. Dyers Col.*, Dec. 1936, P. 470.

Determination of the dispersion of cellulosic fibres by measuring their refractive indices in light of different wave lengths, has indicated that the fibre does not possess a definite refractivity, but that this is dependent upon the nature of the liquid medium in which the measurements are made. Experiments with mixtures of glycerol, or benzyl alcohol, with other liquids indicate that these alcohols gradually become concentrated within the fibre, and this procedure can be applied, therefore, to the optical determination of adsorption. The decrease in refractivity on mercerization corresponds to the widening of the crystal lattice which occurs on conversion of cellulose into hydrated cellulose. (C)

DYES IN RESIDUAL LIQUORS: DIRECT, CHEMICAL AND PHOTOMETRIC METHODS. Thomas Kennedy. *Rayon Tex. Mo.*, Oct. 1936, P. 66–8. Reprint of an article from *The Dyer*. (C)

ELASTICITY OF FIBRES, YARNS AND FABRICS: DETERMINATION OF THE WORKING PROPERTIES AND THE DEGREE OF. F. Kurtz. *Mell. Textilber.*, 1936, P. 195; *Rayon Tex. Mo.*, July 1936, P. 87.

The author describes a novel elasticity testing instrument which he has designed and gives the results of a large number of tests showing the effect of various processes upon the total working properties and the degree of elasticity. (C)

GLOSS: METHODS OF DETERMINING. Richard S. Hunter. *B. S. J. Rsch.*, Jan. 1937, P. 19–39.

The article suggests that the designer of a prospective gloss meter should determine from goniophotometric data taken on representative samples what differences in apparent reflectance are most characteristic of the differences in glossiness observed visually. That is, gloss-meter design will have considerably less of the trial-and-error element when goniophotometric data are used to indicate the most pertinent reflectance measurements to make for various purposes. Also included are descriptions of typical gloss instruments, descriptions of measurements they make, and a bibliography on gloss. Differences between the various types of [illegible] are analyzed in some detail. (C)

V. Economics, Physics and Miscellany

Cotton Textile Problem. Peter M. Strang. *Cotton*, Jan. 1937, P. 58–9.

Tabulates and shows the effect of some of the changes which have affected different divisions of the cotton industry. (C)

Current Research of U. S. Institute for Textile Research. Charles H. Clark. *Am. Dye. Rptr.*, Nov. 30, 1936, P. 639–40. (C)

Japanese Finishers are Pioneering in Use of Electrically Heated Equipment. Herbert Leopold. *Tex. Wld.*, Jan. 1937, P. 91–2.

Brief description of use of electrically heated elements for tenters, singers, can-dryers and calenders. (C)

Microbiology of Textiles: Review of Recent Progress in. Wm. G. Chace. *Am. Dye. Rptr.*, Nov. 30, 1936, P. 652–53. (C)

Relative Humidity: Notes on Comparing Hygrometer and Psychrometer Readings on. R. H. Brown. *Tex. Wld.*, Aug. 1936, P. 77–8. (C)

Research Work of A. A. T. C. C. Louis A. Olney. *Am. Dye. Rptr.*, Nov. 30, 1936, P. 640–43. (C)

Starch Products: Evaluation of—Used in the (Paper Pulp) Beater and Tub. J. P. Strasser. *Paper Trade J.*, Feb. 4, 1937, P. 35–44.

Paper presented at the annual meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 22–25, 1937. (C)

Textile Research: Progress Review of American. Charles H. Clark. *Rayon Tex. Mo.*, Sept. 1936, P. 53–4. (C)

Why Textile Research? E. H. Killheffer. *Am. Dye. Rptr.*, Nov. 30, 1936, P. 637–39; *Tex. Rsch.*, Dec. 1936, P. 79–82; *Tex. Bull.*, Nov. 19, 1936, P. 6, 24–5; *Fibre & Fabric*, Nov. 14, 1936, P. 8–10; *Tex. Col.*, Dec. 1936, P. 803–4, 852; *Am. W. & C. Rptr.*, Nov. 12, 1936, P. 12–15.

Address before annual dinner of U. S. Institute for Textile Research, Inc., Nov. 5, 1936. (C)

Book Review

A. S. T. M. Standards on Textile Materials. American Society for Testing Materials, Philadelphia, Pa. Oct. 1936. Pp. 275. Price $2.

This 1936 edition, prepared by Committee D–13 on Textile Materials, brings the work of this committee up-to-date, and contains in addition to all A. S. T. M. textile standards a proposed potassium dichromate oxidation method for the determination of total iron in asbestos textiles, a psychrometric table for relative humidity which combines both accuracy and convenience to an exceptional degree, a section comprising many excellent photo-micrographs of common textile fibres and a convenient yarn number conversion table. Also included are proposed methods covering the testing

of wool felt and correction of breaking strength to standard regain. It also contains for the first time new methods of testing applying to pile floor covering; fineness of wool; corded cotton gray goods; yarn slippage in silk, rayon and silk-rayon woven broad goods; and fastness to laundering or domestic washing of dyed or printed cotton fabrics and printed silk or rayon fabrics. (C)

(*Continued from P. 228.*)

conference on the subject was held in conjunction with U. S. Institute's annual meeting last November. Both of the conferences were the source of a large amount of valuable literature on the subject all of which was published in TEXTILE RESEARCH and in the trade press of this and foreign countries. The wide publicity thus given to the need of such a study has exerted much the same valuable influence as that which has followed U. S. Institute's study of sizing and sizing materials: It has already caused many mills to survey and attempt to improve their drying, and has been followed by important improvements in drying machinery and control instruments.

Prof. George B. Haven Honored

A NOTABLE feature of the Spring meeting of Committee D–13 of the American Society for Testing Materials at Providence, R. I., Mar. 11–13, was the testimonial dinner to George B. Haven, S.B., who retired last year as Professor of Advanced Machine Design at Massachusetts Institute of Technology, as a member of A. S. T. M., and an active member of Committee D–13, to which he has been elected an honorary member. Some 100 members and guests were present to honor Prof. Haven. Prof. H. J. Ball, chairman of Committee D–13, presided at the dinner; Daniel E. Douty, president, U. S. Testing Co., Hoboken, N. J., acted as toastmaster; Russell T. Fisher, president, National Association of Cotton Manufacturers, introduced Prof. Haven, and E. D. Walen, agent, Worsted Division, Pacific Mills, Lawrence, Mass., presented to the guest of honor a handsome framed and hand-illuminated, engrossed scroll recording a resolution prepared by the Advisory Committee.

As Chairman of Committee D–13 during its formative period, 1917–1920, and as an indefatigable worker in the interests of the Committee during the 17 intervening years, Prof. Haven is credited with a leading part in molding its policies, in establishing its technical activities on a high level, and in expanding it to one of the leading committees of the Society, both in numbers and in volume and quality of results.

Prof. Haven, in response, outlined the progress in textile standardization and testing instrumentation from 1917, when he became chairman of the Committee for three years, interspersing his remarks with intimate and witty reminiscences of that formative period. A notable feature of his address was his reference to a large number of testing instruments and techniques, and of improvements in those now in common use, that are needed to place textile testing and research upon a scientific basis.

The committee on arrangements for the dinner was as follows: K. B. Cook, D. E. Douty, C. B. Finckel, H. J. Jaquith, D. C. Scott, W. H. Whitcomb.